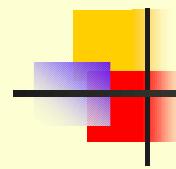


Overview of Today's Presentation:

- Review TMDL concepts
- Watershed characterization
- Discuss the bacteria TMDL Study
 - Identify/quantify potential bacteria sources
 - Link sources to the stream
 - Load Allocations → the TMDL
 - Alternative TMDL Scenarios



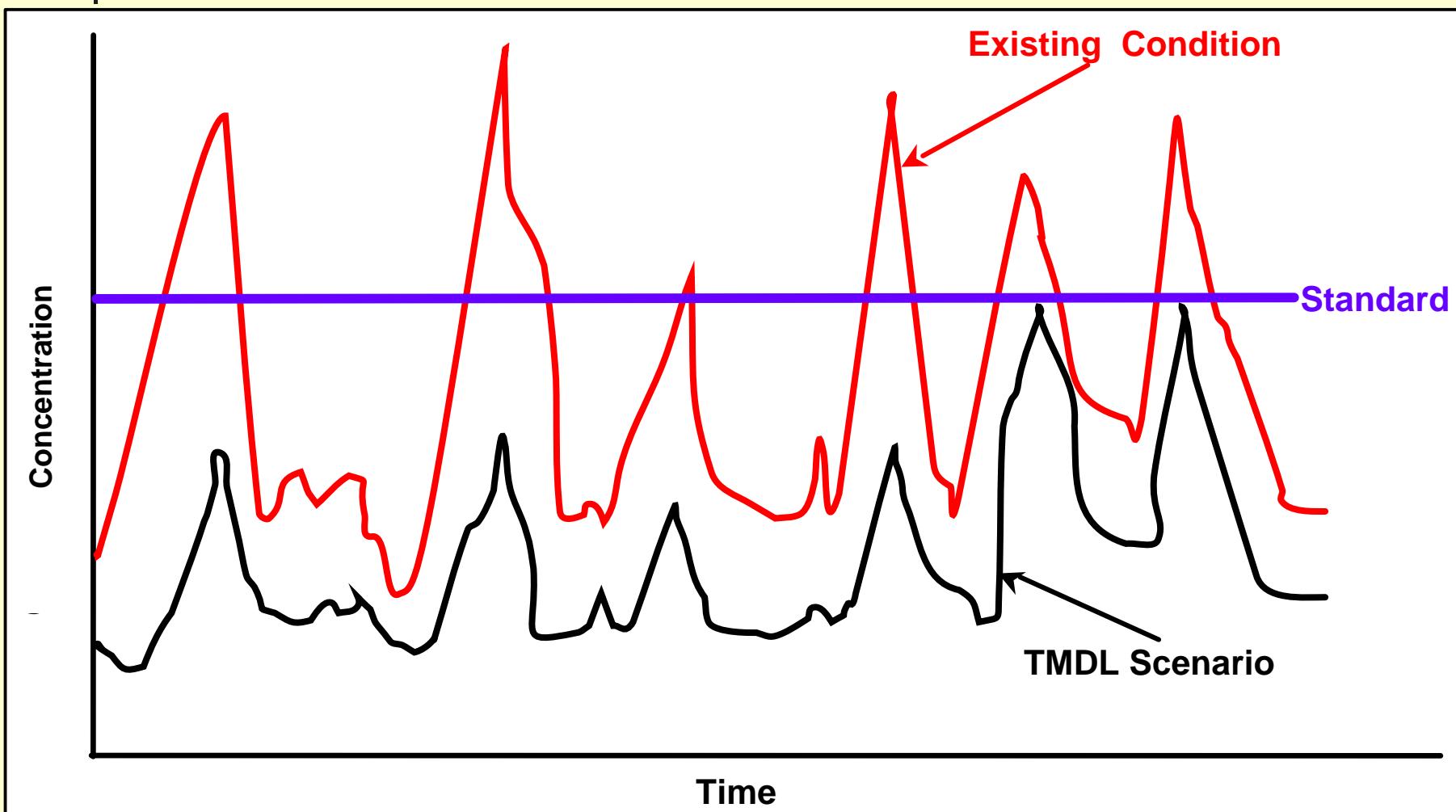
What is a TMDL?

- The maximum amount of pollutant that can enter a water body without negatively affecting its beneficial uses
 - Fishing, swimming, wildlife habitat, aquatic life, shellfish habitat

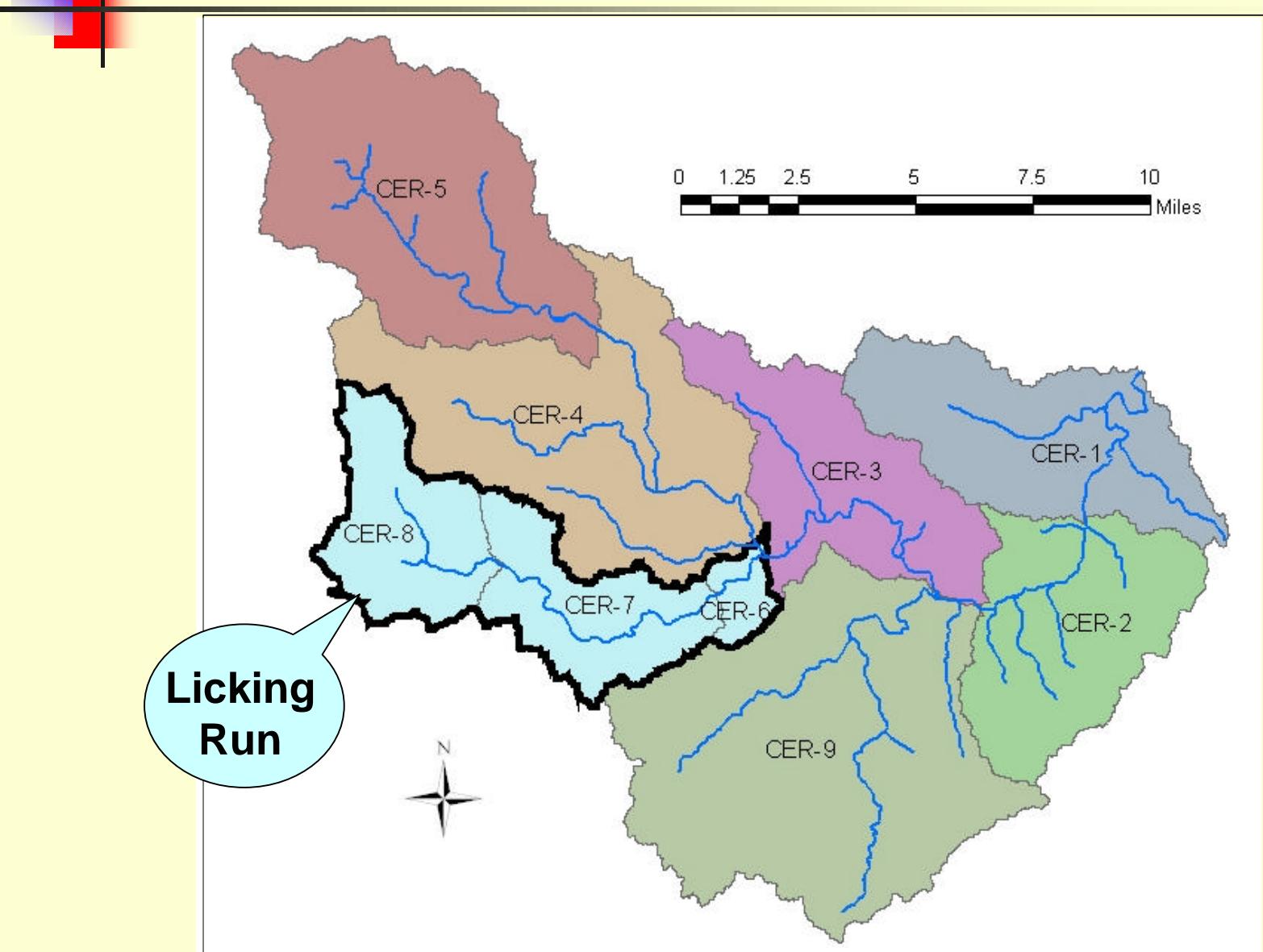
TMDL = point sources + nonpoint sources + margin of safety

$$= \quad \text{WLA} \quad + \quad \text{LA} \quad + \quad \text{MOS}$$

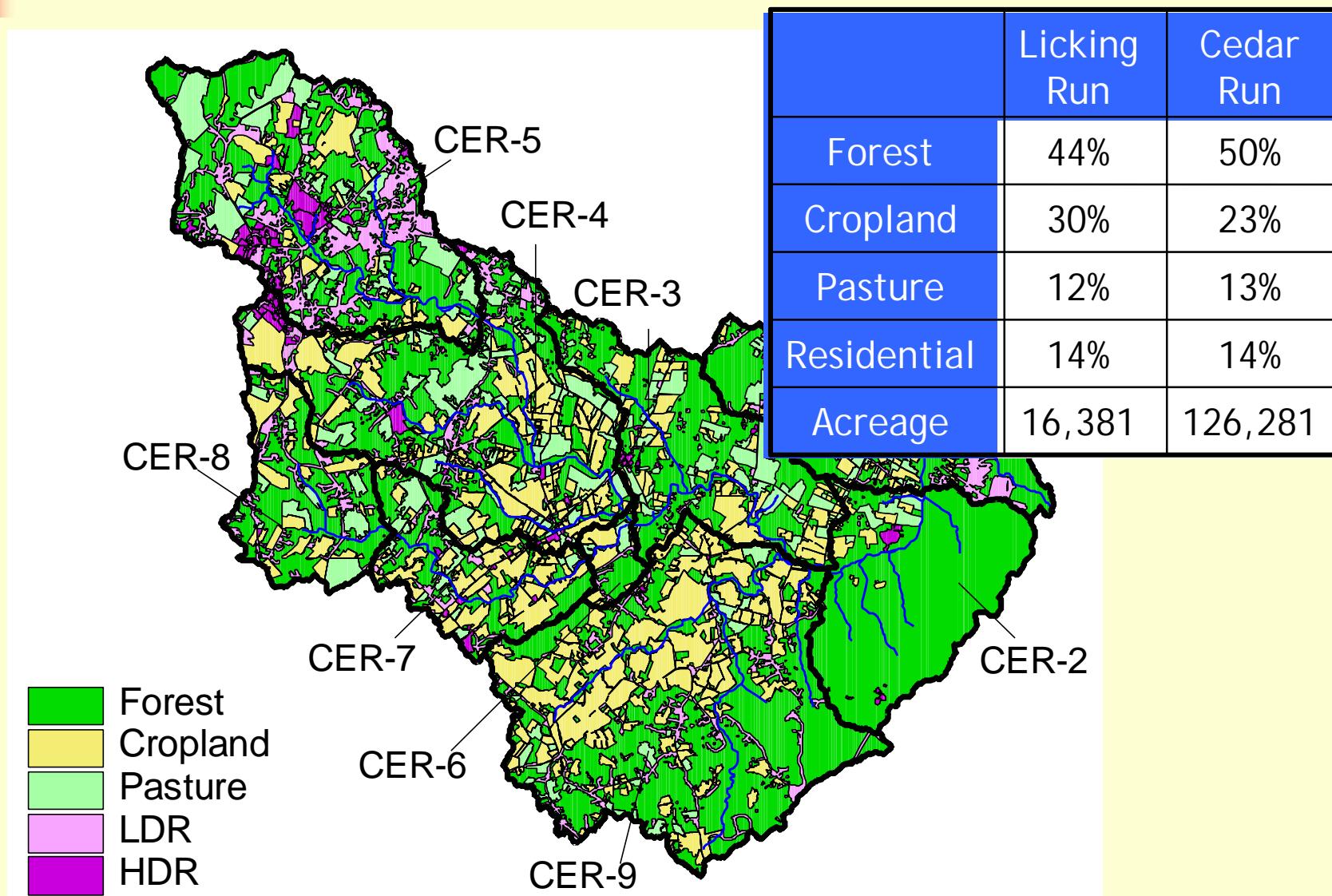
Example Bacteria TMDL



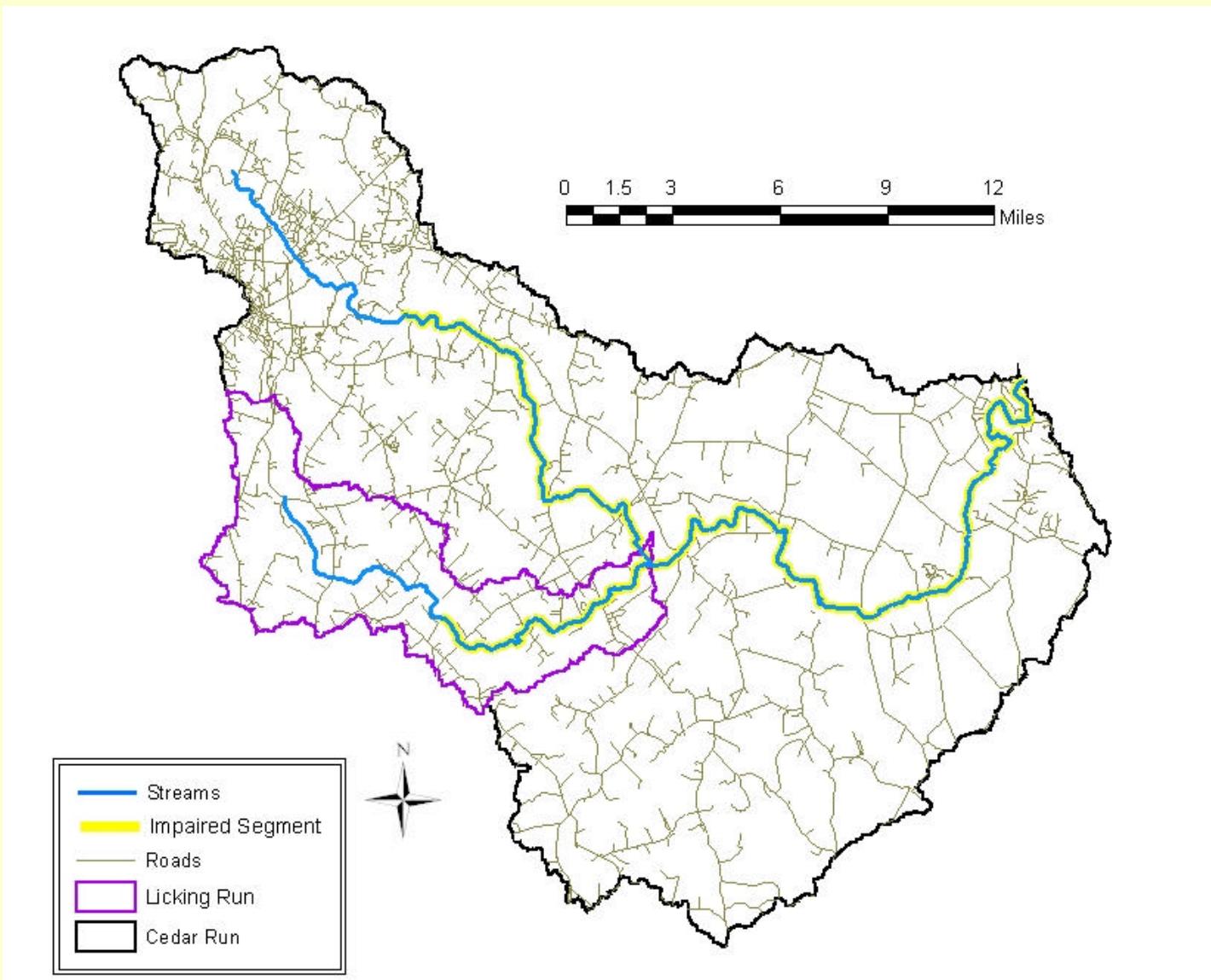
Stream Network and Subwatersheds



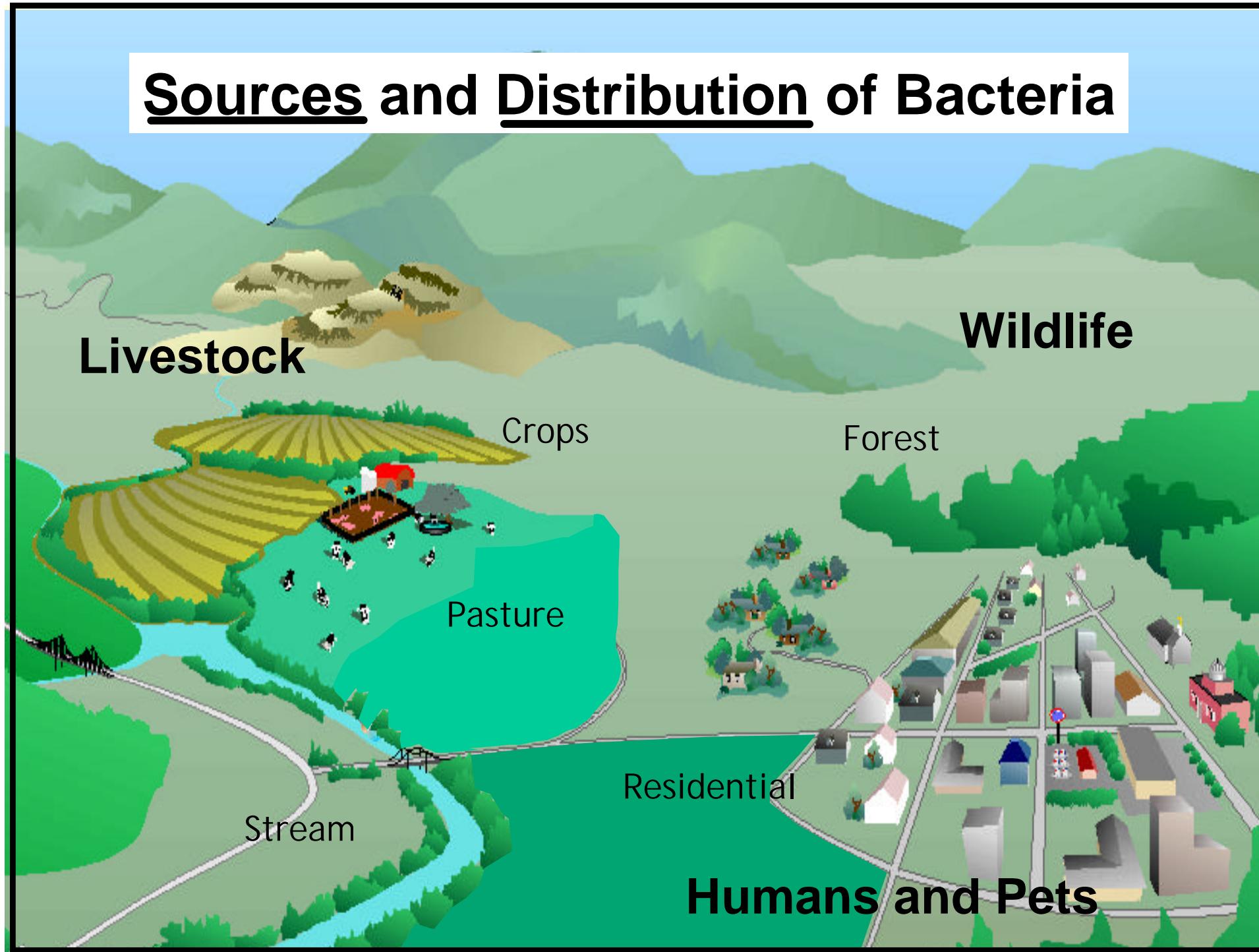
Major Land Uses: Licking Run and Cedar Run



Impaired Segments



Sources and Distribution of Bacteria



Cedar Run

Production and Distribution of Bacteria

Livestock: 94.0%

Wildlife: 3.8%

Crops: 1.1%

Forest: 2.9%

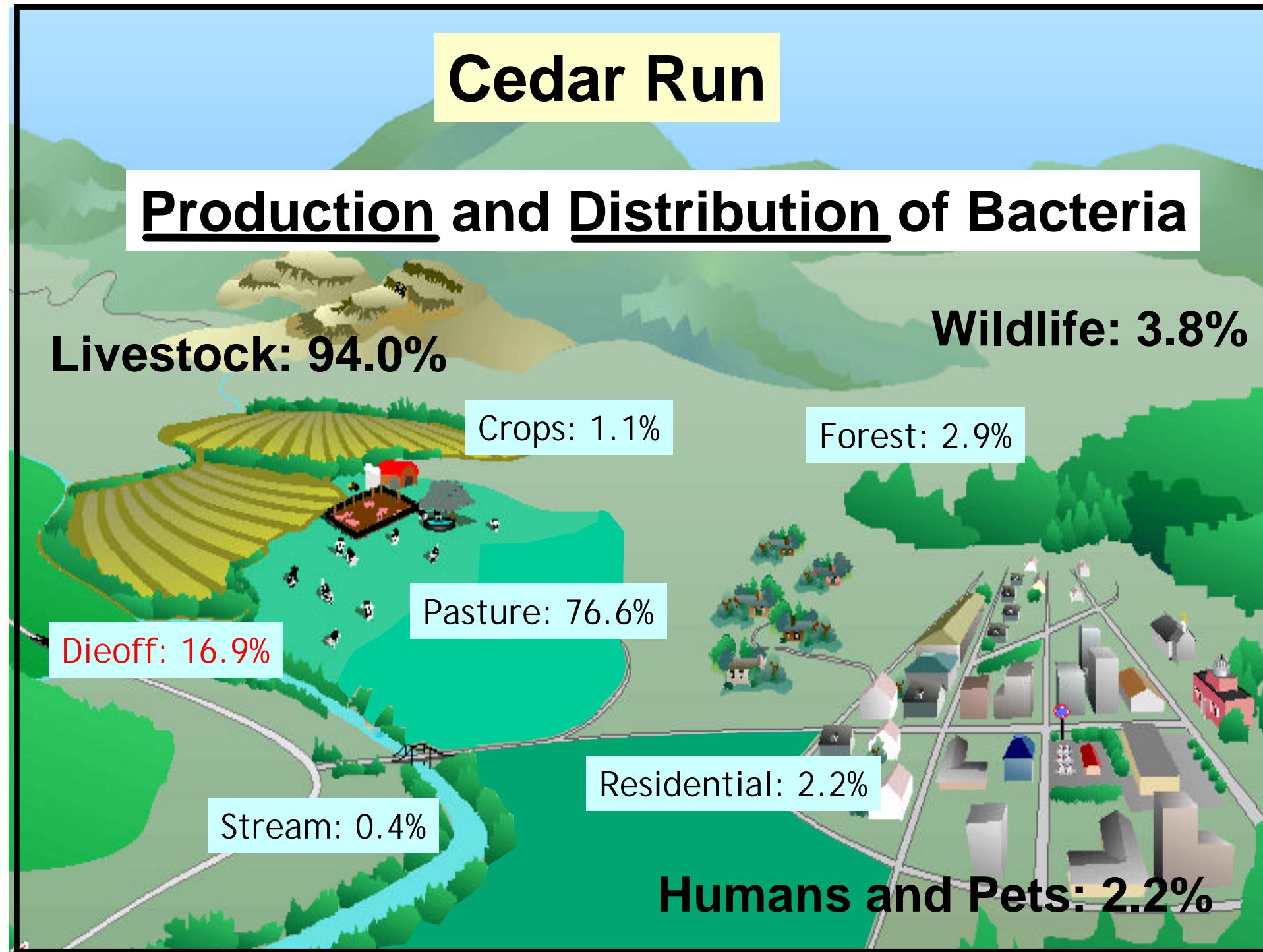
Pasture: 76.6%

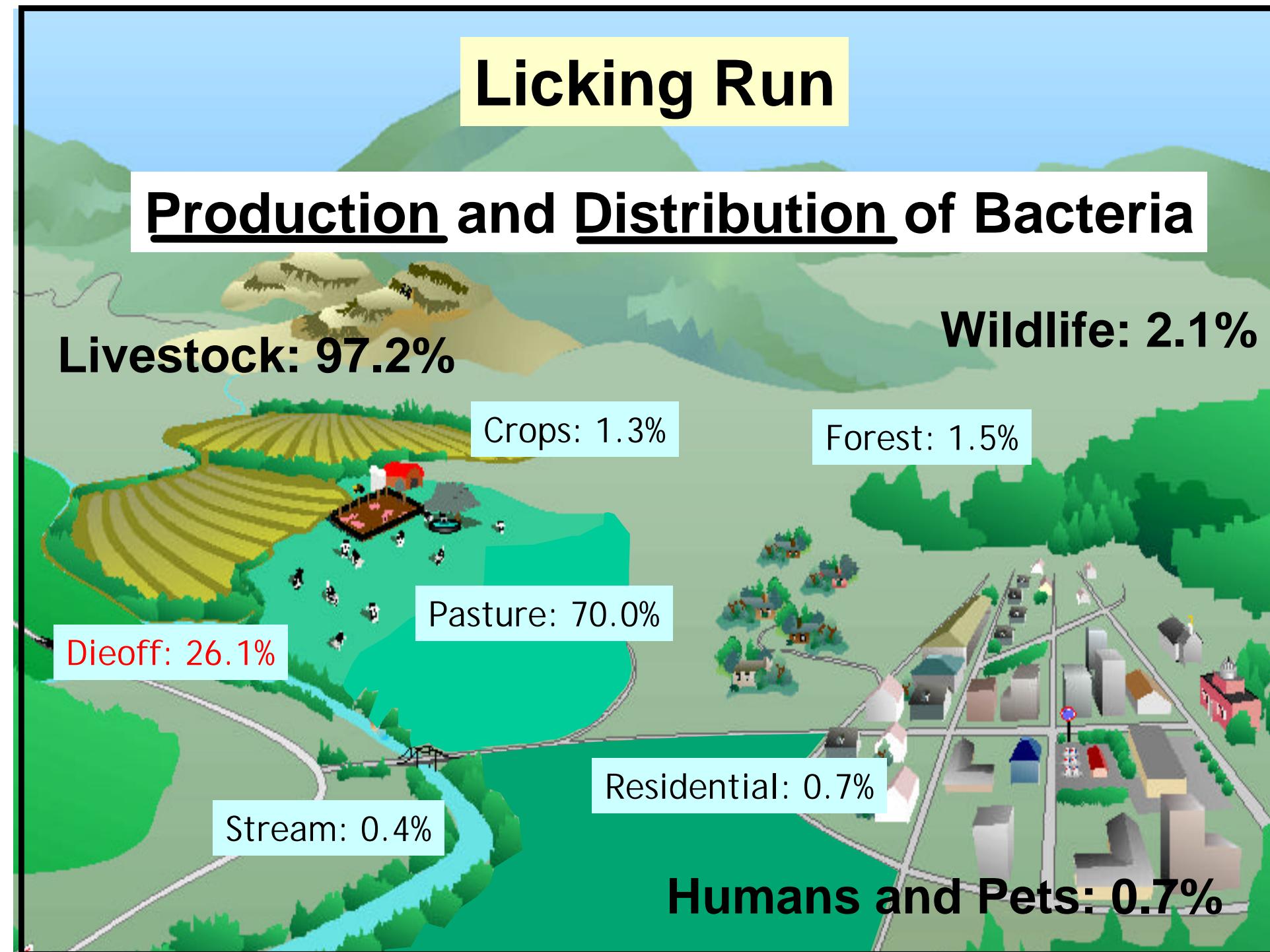
Dieoff: 16.9%

Stream: 0.4%

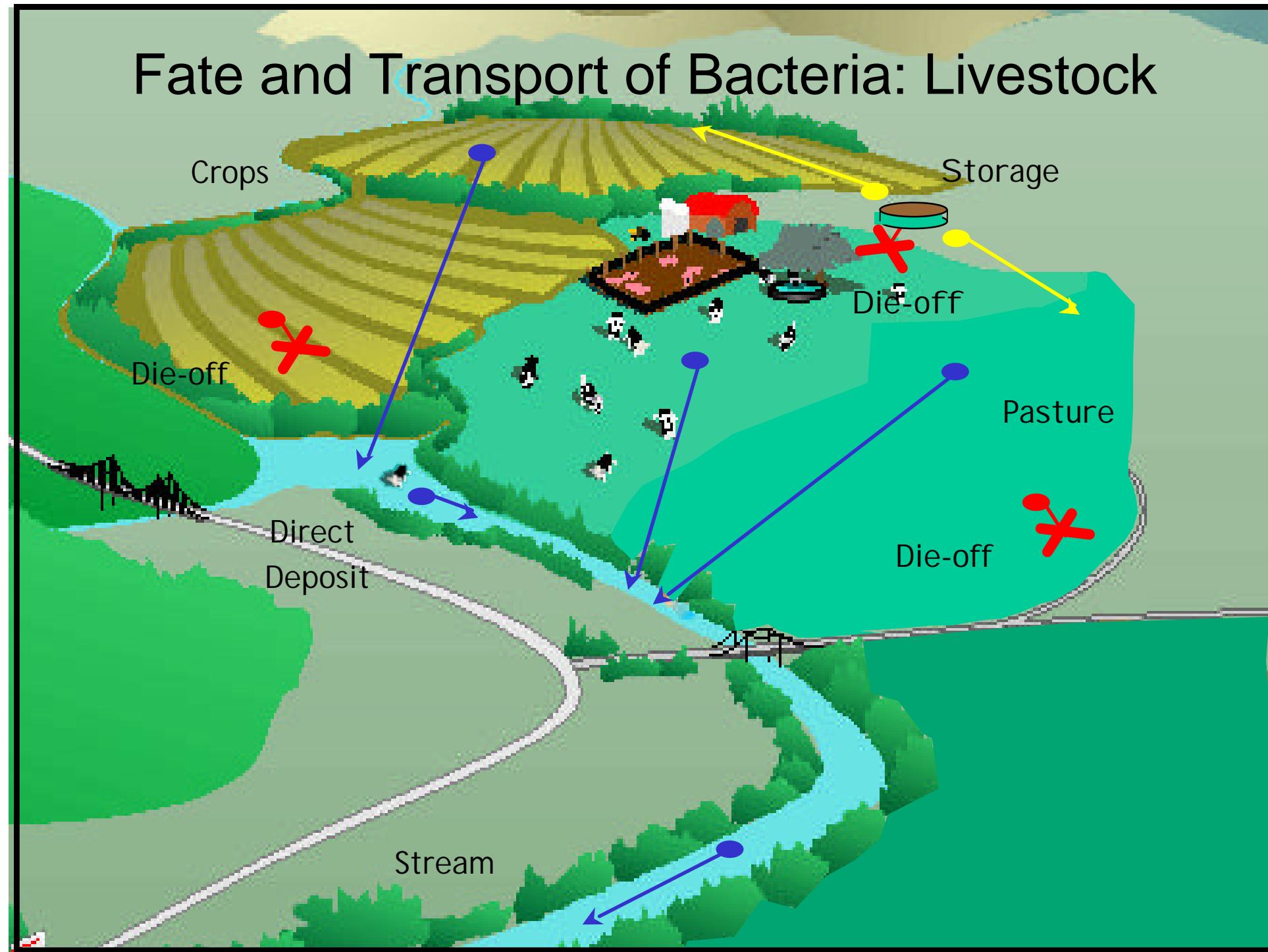
Residential: 2.2%

Humans and Pets: 2.2%





Fate and Transport of Bacteria: Livestock

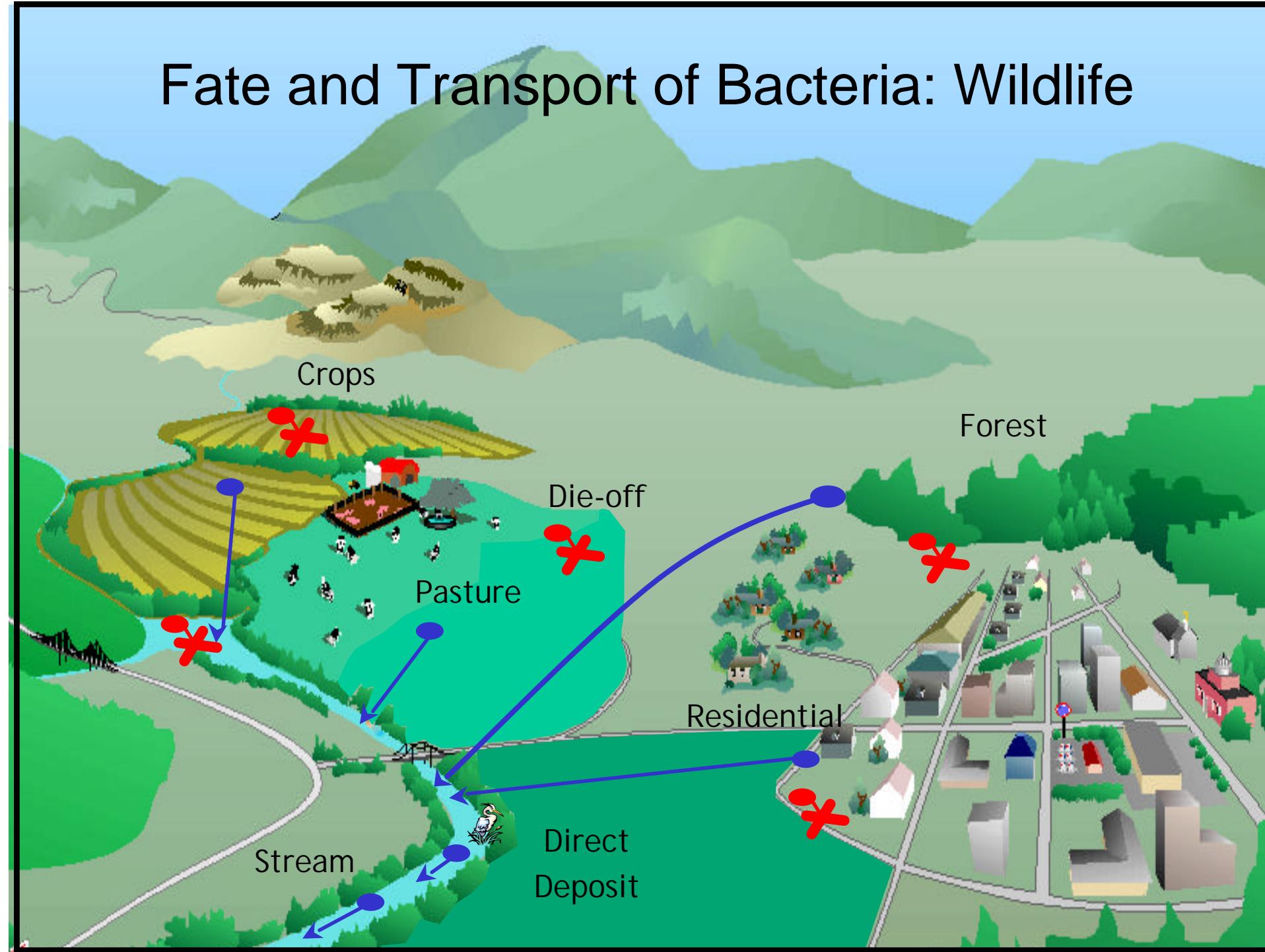


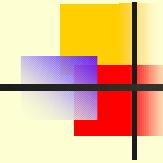
Estimated Livestock Population

Sub-basin	Dairy	Beef	Horses	Poultry	Hogs	Sheep	Goats
CER01	400	150	83	31	9	33	3
CER02	85	80	23	9	2	9	1
CER03	765	225	158	31	9	33	3
CER04	1,885	350	424	69	61	59	8
CER05	330	300	98	37	11	39	4
CER06	55	50	8	3	1	3	0
CER07	930	25	53	20	6	21	2
CER08	220	150	45	17	5	18	2
CER09	1,405	600	174	66	100	68	60
Total	6,076	1,930	1,066	283	204	283	84

- CER06 - CER08 comprise Licking Run

Fate and Transport of Bacteria: Wildlife



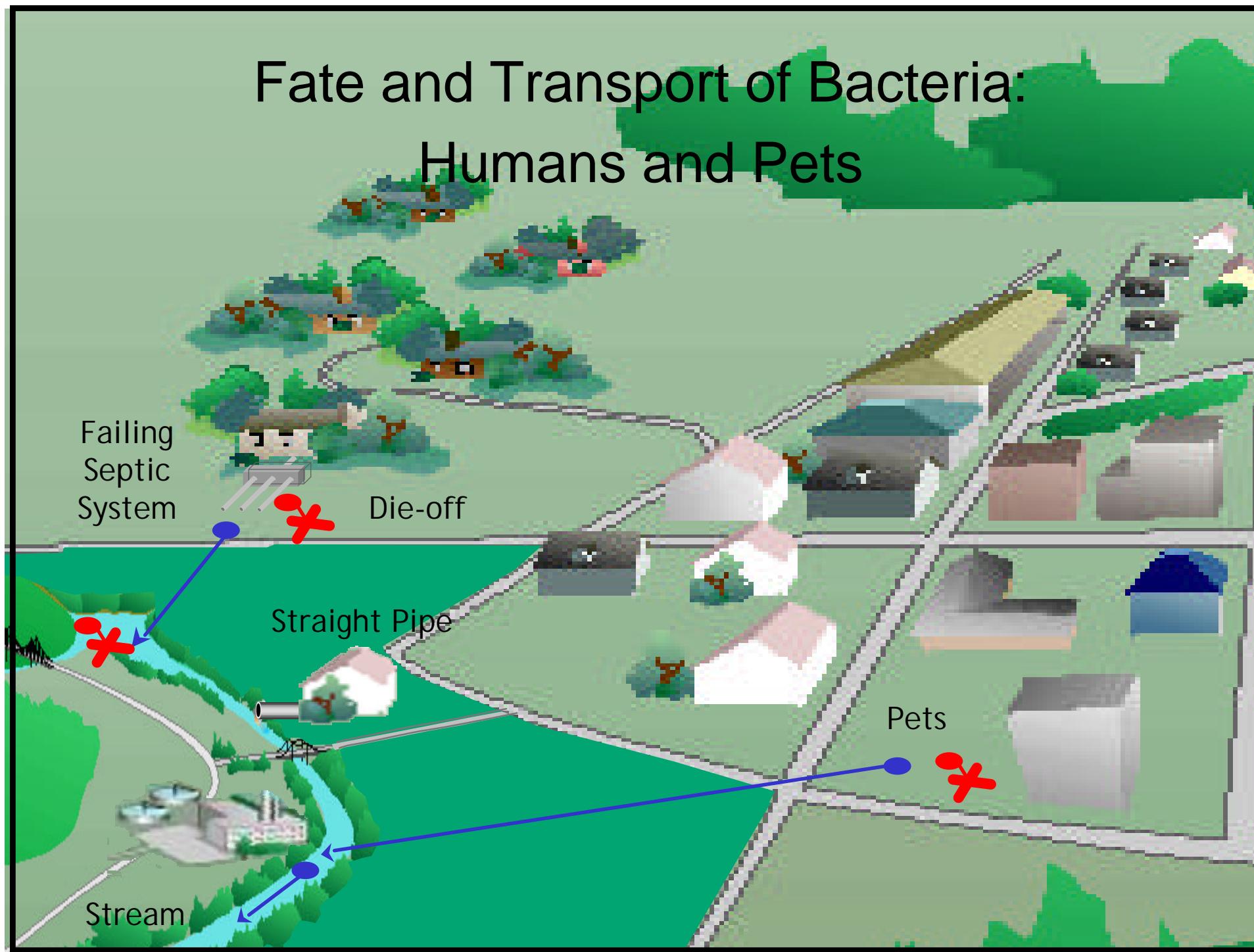


Estimated Wildlife Population

Sub-basin	Beaver	Muskrat	Raccoon	Turkey	Deer	Waterfowl
CER01	58	1,669	337	87	1,263	389
CER02	47	1,481	334	97	930	451
CER03	48	1,592	348	53	909	213
CER04	77	2,283	504	76	1,601	1,234
CER05	64	1,947	437	89	1,411	2,546
CER06	3	121	27	6	106	0
CER07	18	578	131	24	494	356
CER08	27	899	205	41	624	87
CER09	80	2,566	574	125	1,998	76
Total	422	13,136	2,937	599	9,336	5,352

- CER06 - CER08 comprise Licking Run

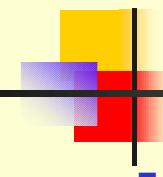
Fate and Transport of Bacteria: Humans and Pets



Human and Pet Bacteria Sources

Sub-basin	Human Population	Houses	Failing Septic Systems	Pets (1/house)
CER01	2,453	853	17	853
CER02	359	130	3	130
CER03	1,037	385	32	385
CER04	4,197	1,639	175	1,639
CER05	10,789	3,983	80	3,983
CER06	128	48	1	48
CER07	588	218	4	218
CER08	1,474	514	10	514
CER09	1,794	656	13	656
Total	22,821	8,425	335	8,425

- CER06 - CER08 comprise Licking Run



Quantification of Bacteria

■ Total daily number of coliform produced

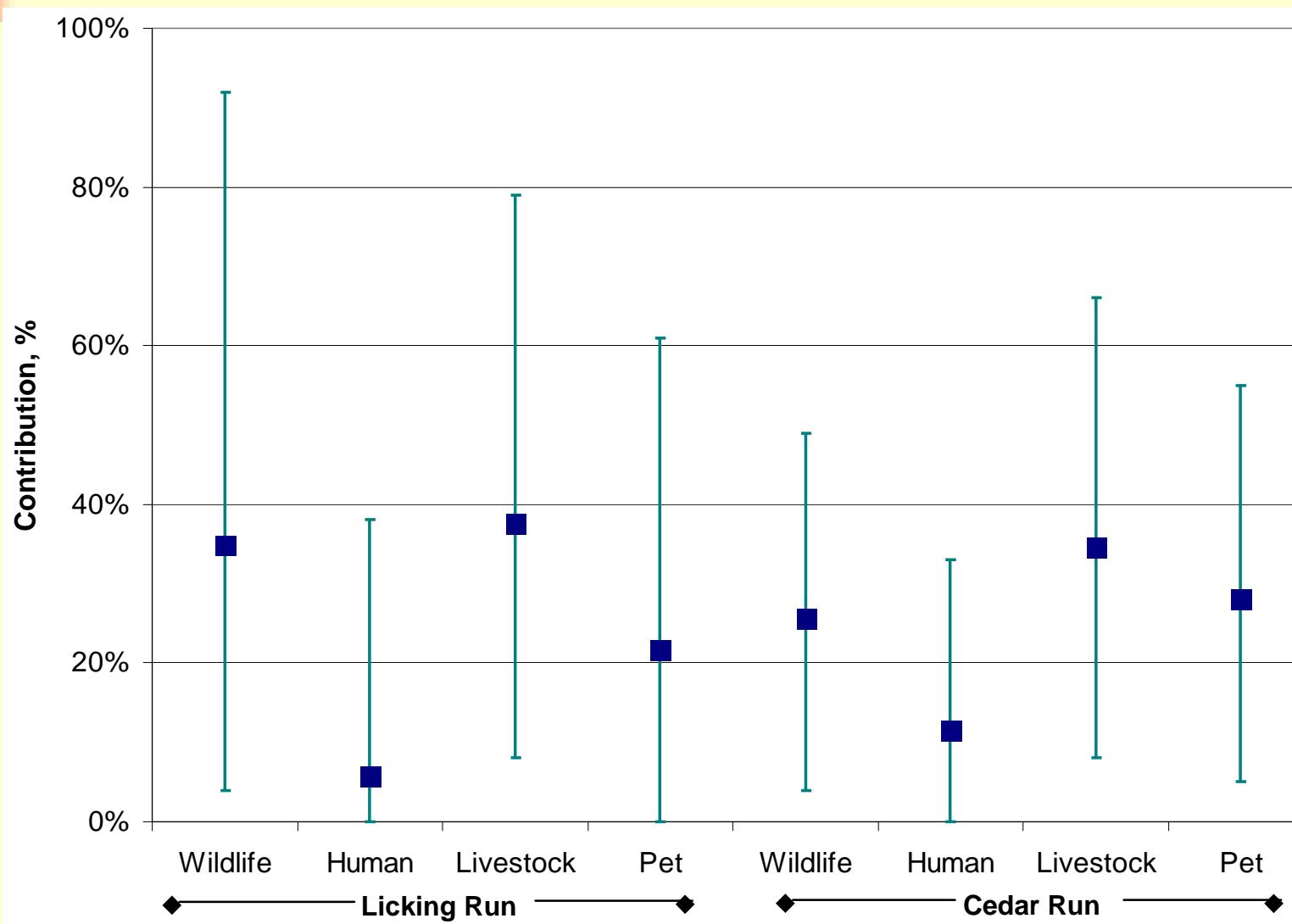
Number of animals x daily coliform produced per animal

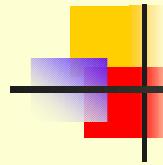
(Million Per Animal Per Day)

Beef	33,000
Muskrat	25
Beaver	0.2
Deer	347
Raccoon	50
Goose	800
Human	1,950

- Distribution - spatial and temporal
- Die off - on land, in storage, and in streams

BST Results





Bacteria Impairments: Linking Bacteria Sources to Water Quality in the Stream

Using Computer Models to Develop TMDLs

INPUT

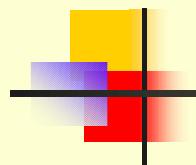
- Soils
- Weather
- Land-use
- Pollutant sources

MODEL

Models are used to predict how
watersheds respond and to evaluate
pollutant reduction options

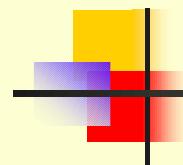
OUTPUT

- Runoff
- Bacteria load



Link Sources to the Stream

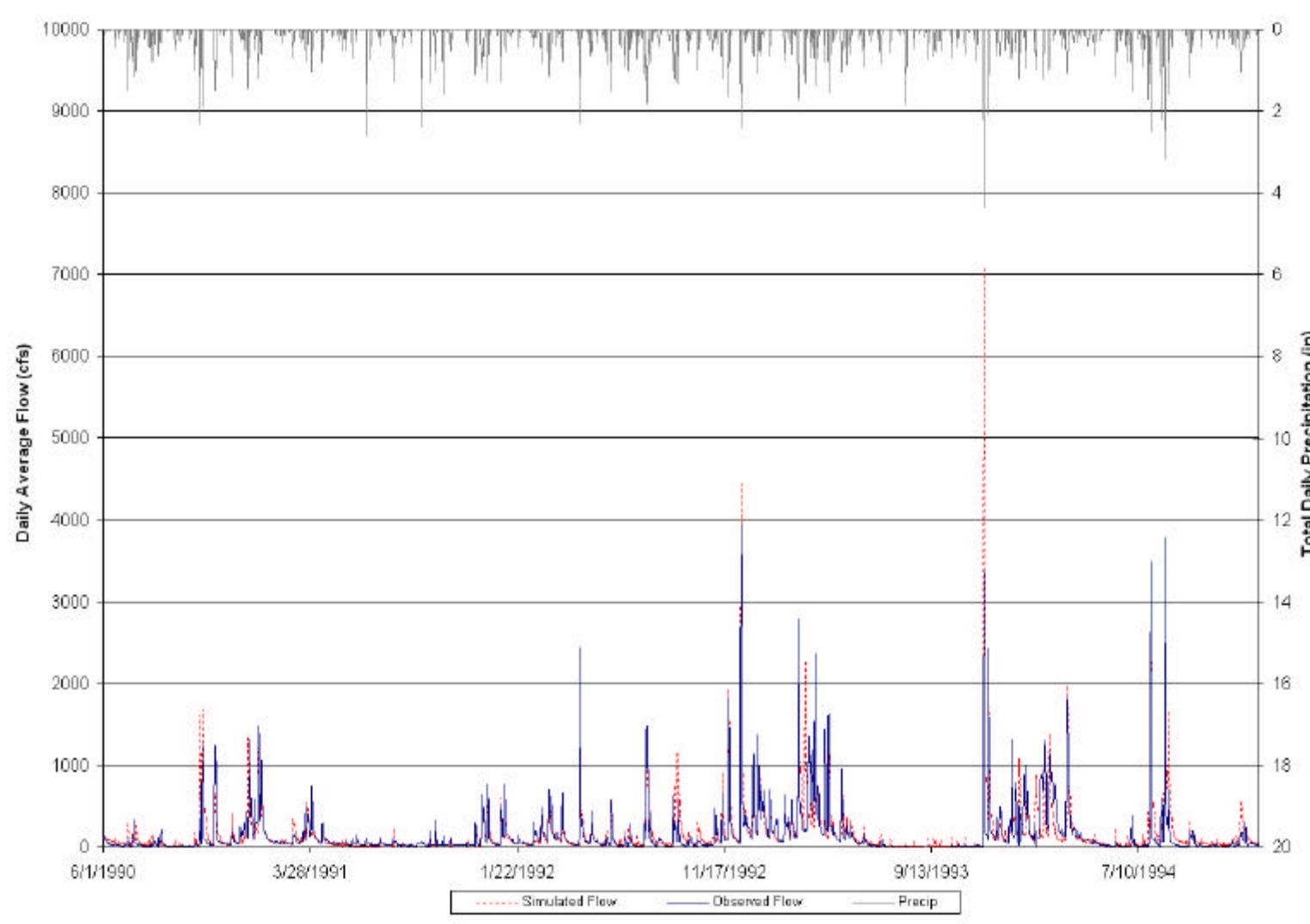
- HSPF Model
 - Watershed model
 - Variability in weather
 - Point and nonpoint sources
 - Simulates fecal coliform die-off
 - Tracks fecal coliform transport from land to the stream
- Model Calibration
 - Hydrology
 - Water quality



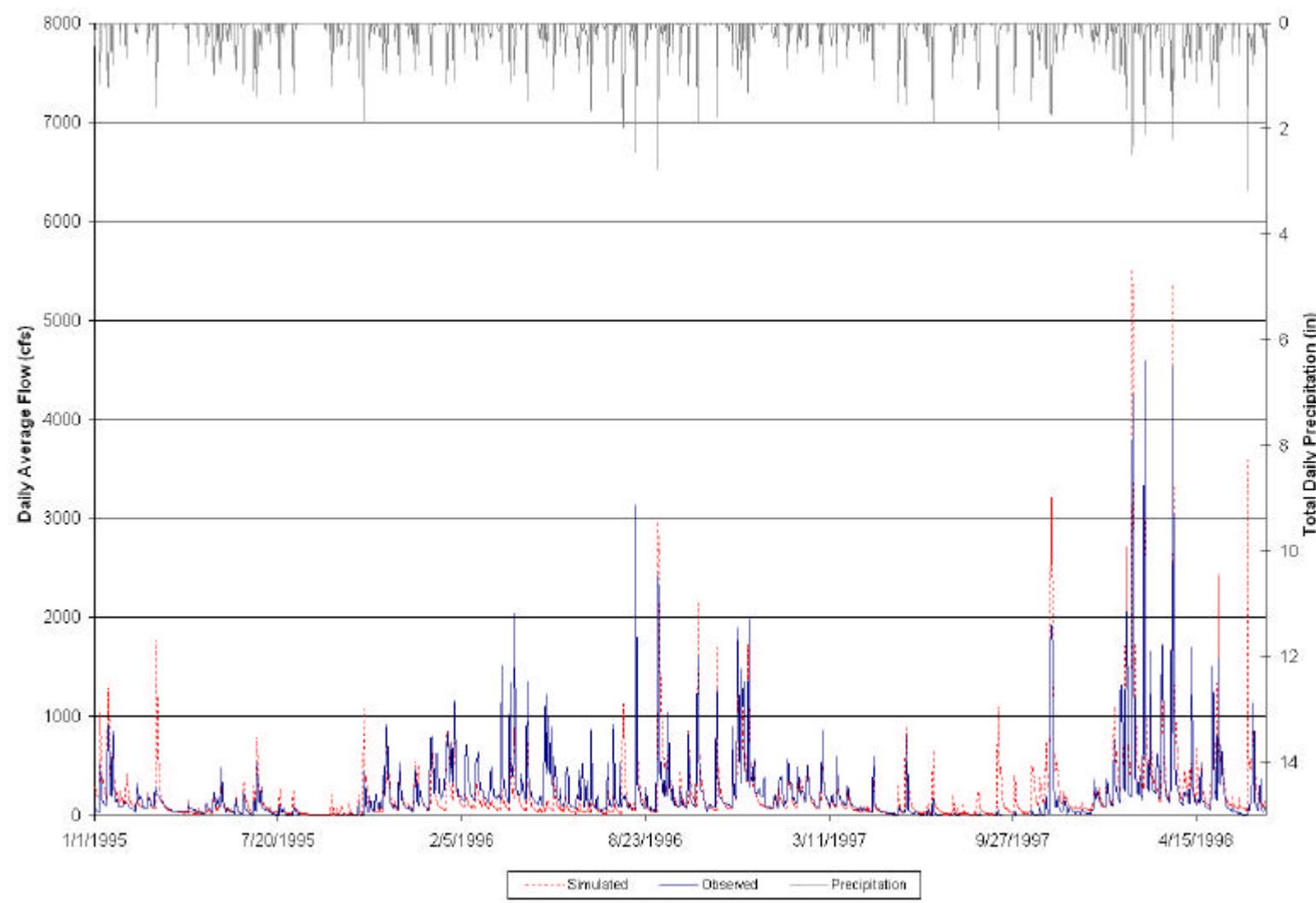
HSPF Calibration and Validation

- Calibration – Process to ensure that model accurately represents watershed conditions
 - Compare model predictions to observed data
 - Adjust model values if needed
- Validation - Process to ensure that calibrated parameters are appropriate for time periods other than the calibration period

Hydrology Calibration: Cedar Run



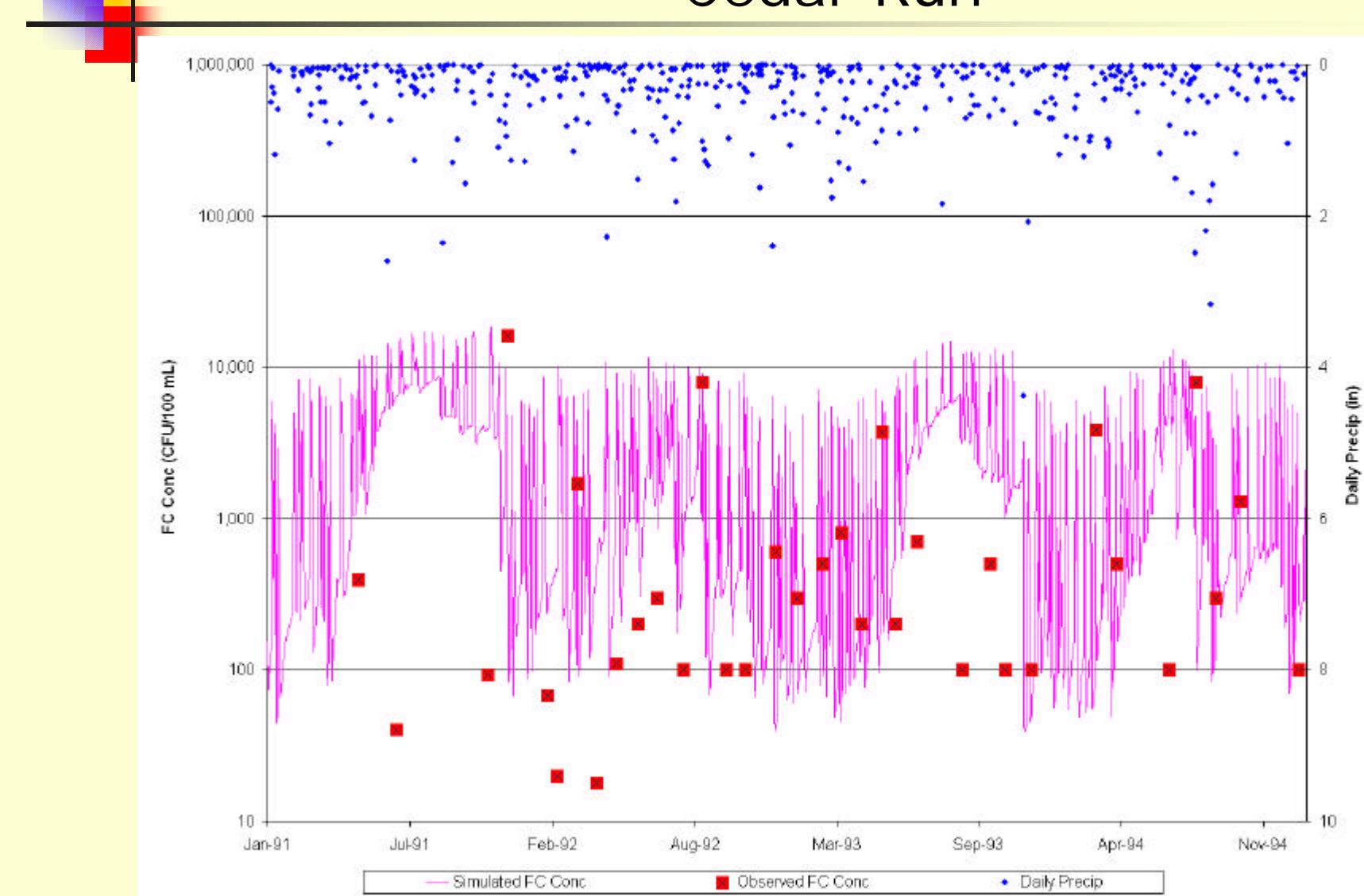
Hydrology Validation: Cedar Run



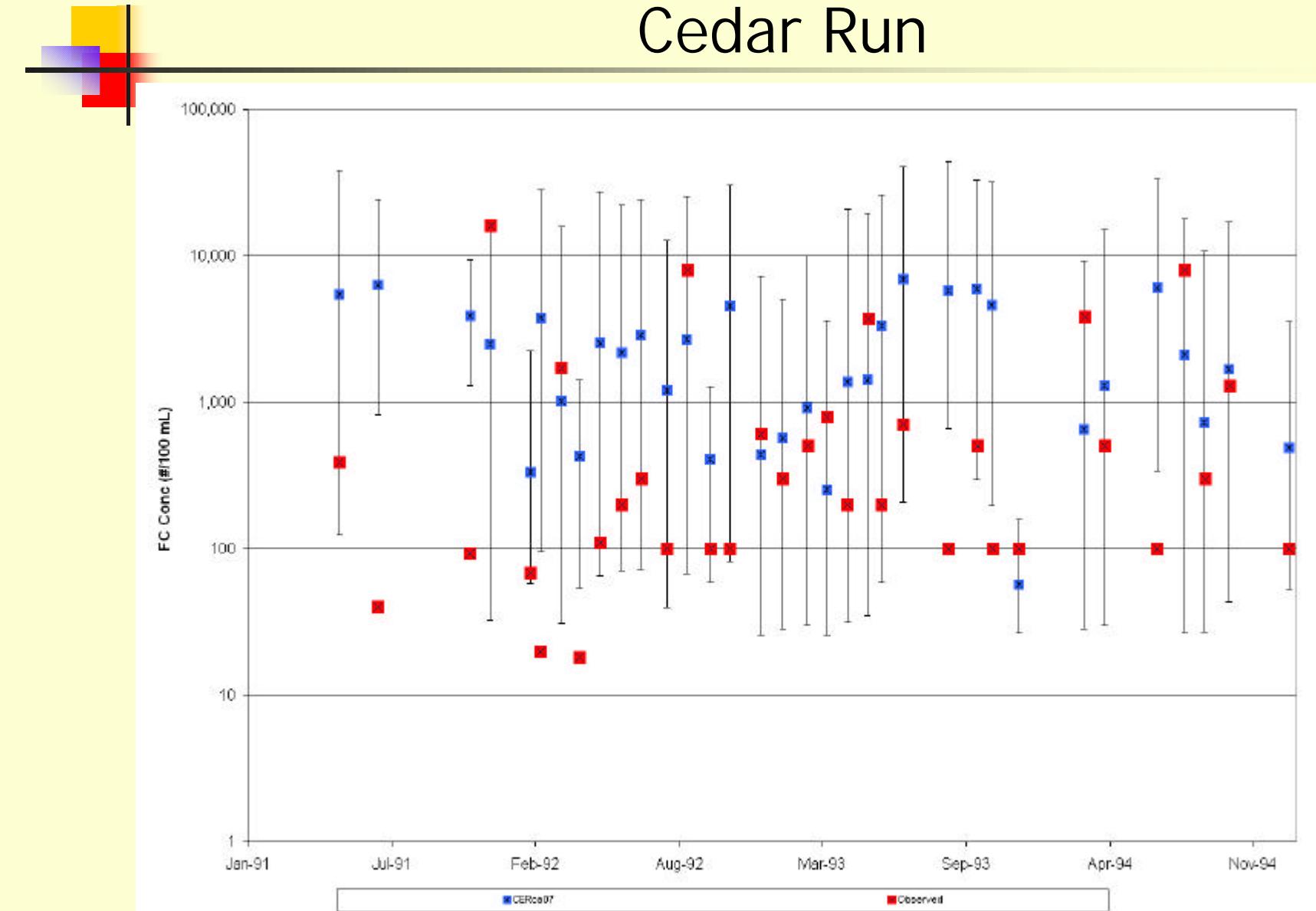
Hydrologic Calibration/Validation Statistics: Cedar Run

	Calibration Error, %	Validation Error, %	Criterion, %
Total Runoff	4.3	8.3	±10
Average Annual Total Runoff	4.3	8.3	±10
Total of Highest 10% of Flows	-3.7	7.4	±15
Total of Lowest 50% of Flows	22.3	20.7	±15
Low Flow Recession	-0.06	-0.03	±0.01
Storm Peaks	-9	-5.9	±15
Seasonal Volume	30.6	24	±10
Summer Storm Volume	-7.5	-10	±15

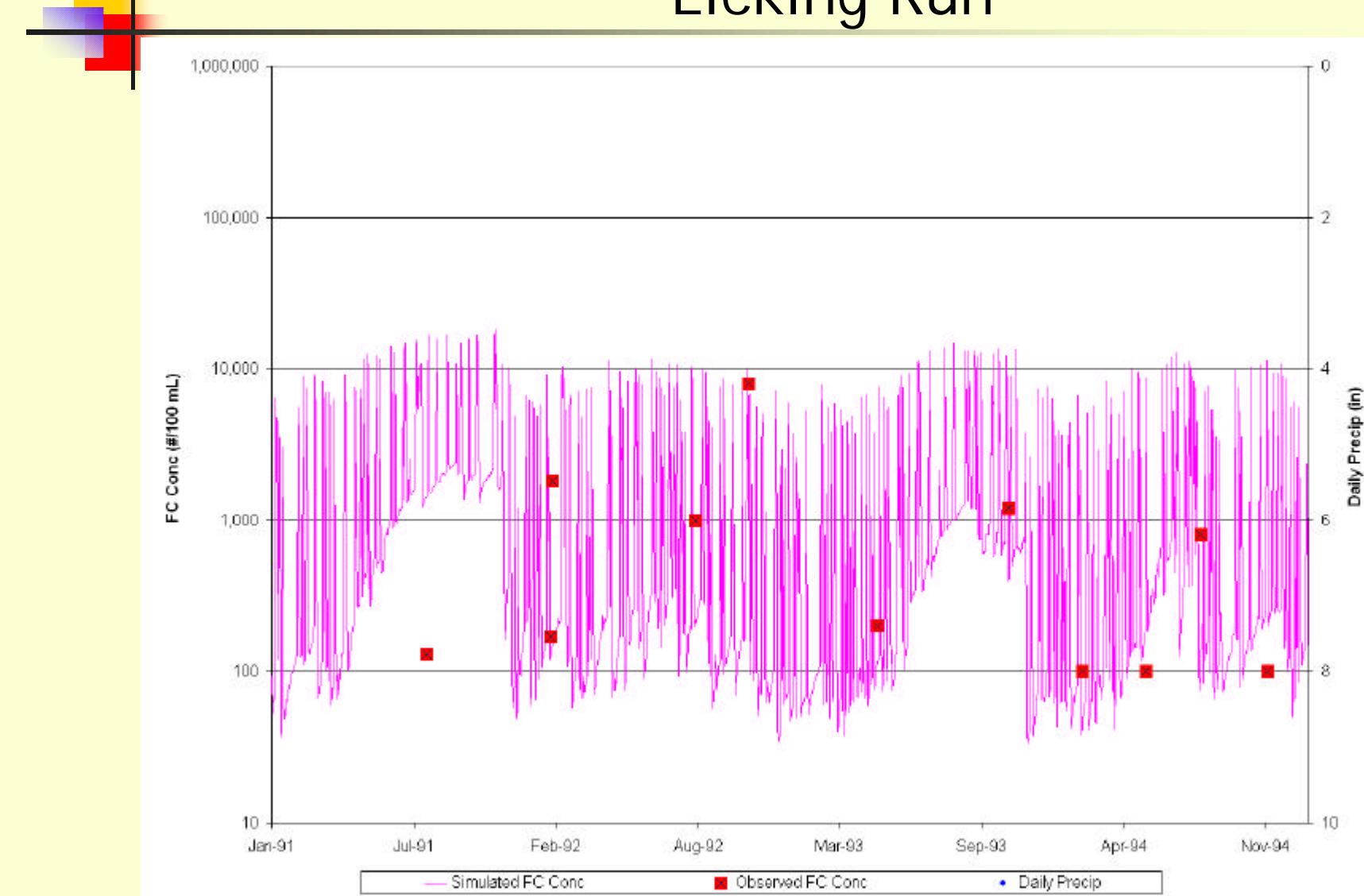
Fecal Coliform Calibration - Cedar Run



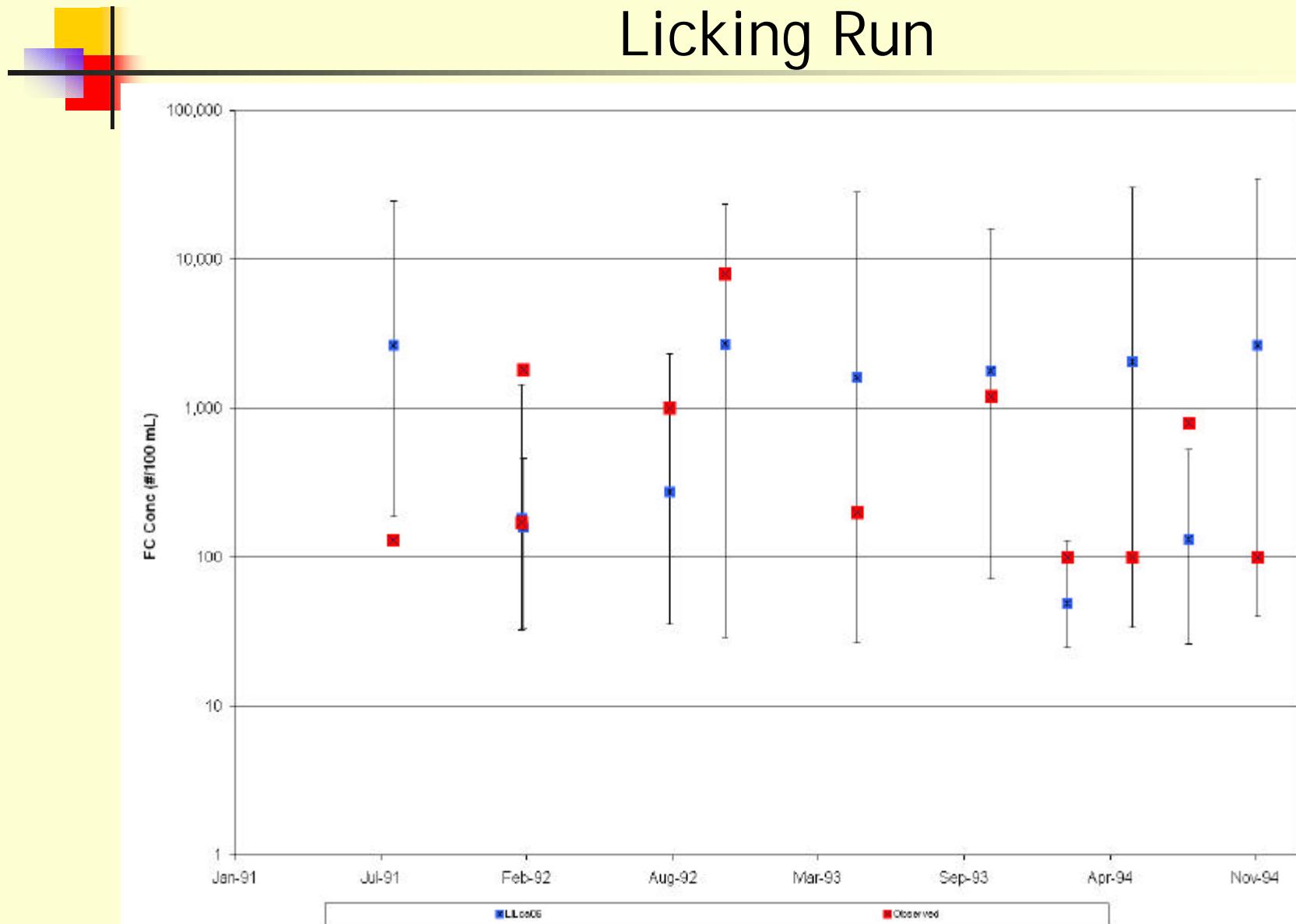
Fecal Coliform Calibration - Cedar Run

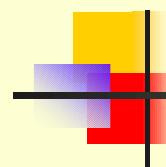


Fecal Coliform Calibration - Licking Run



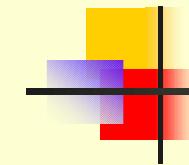
Fecal Coliform Calibration - Licking Run





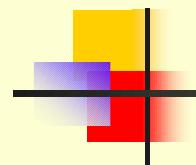
Calibration and Validation dates

	Hydrology		Bacteria
	Calibration Dates	Validation Dates	Calibration Dates
Cedar Run	June 1, 1990 - December 31, 1995	January 1, 1995 - June 30, 1998	January 1, 1991 - December 31, 1994
Licking Run	N/A	N/A	January 1, 1991 - December 31, 1994



Evaluate alternative load reduction scenarios

- Task: To identify scenarios that achieve water quality standards
- Assess alternative ways to meet TMDL goal
- Consult with:
 - Local, state and federal agencies
 - Citizen groups
 - Landowners

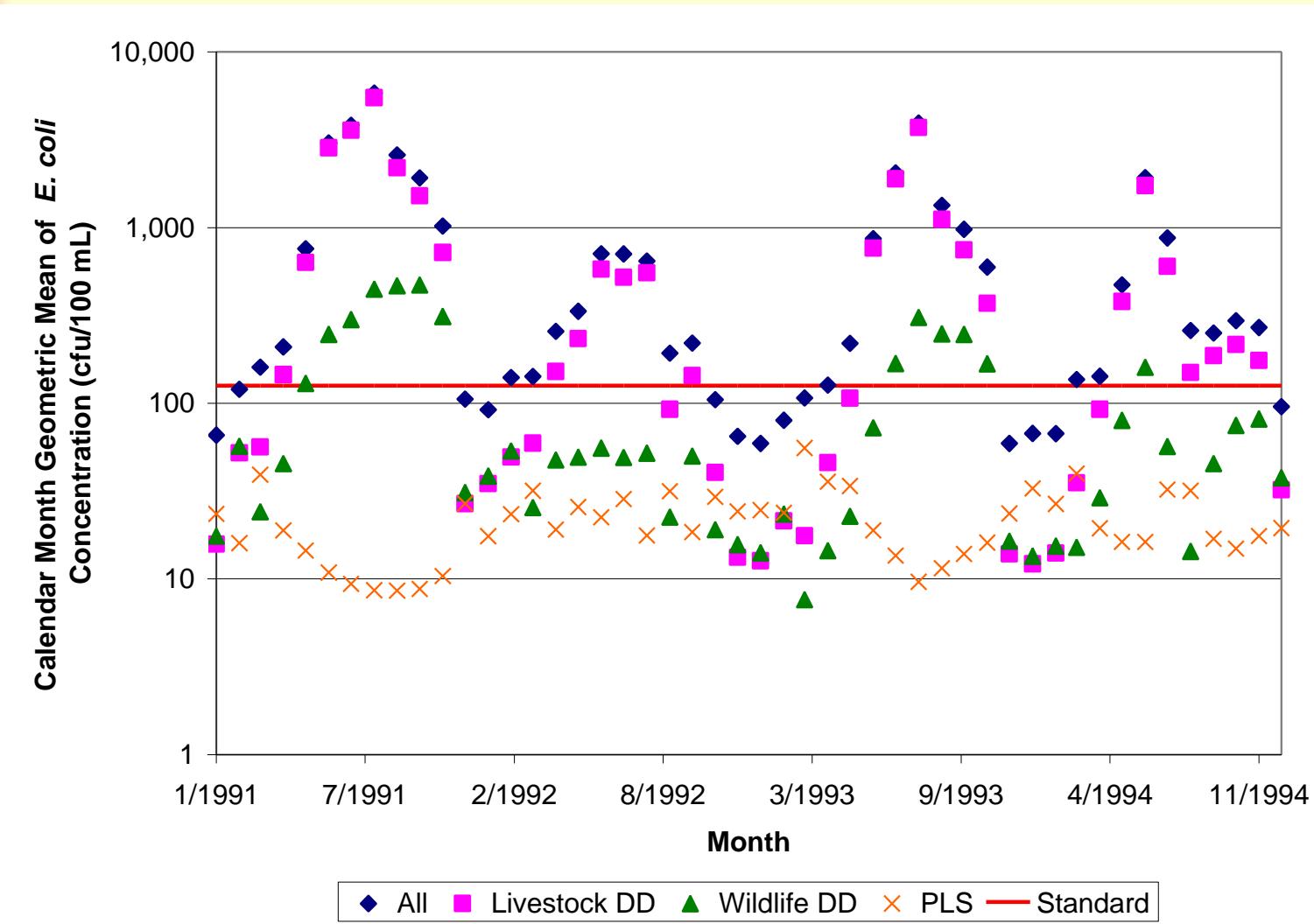


Bacteria Load Allocation

- Identify reductions from existing sources to meet water quality standards
- Direct contributions
 - Permitted point sources
 - Animals in the stream
- Indirect contributions
 - Forest
 - Cropland
 - Pasture
 - Residential

Contribution by Source Category - Licking Run

32

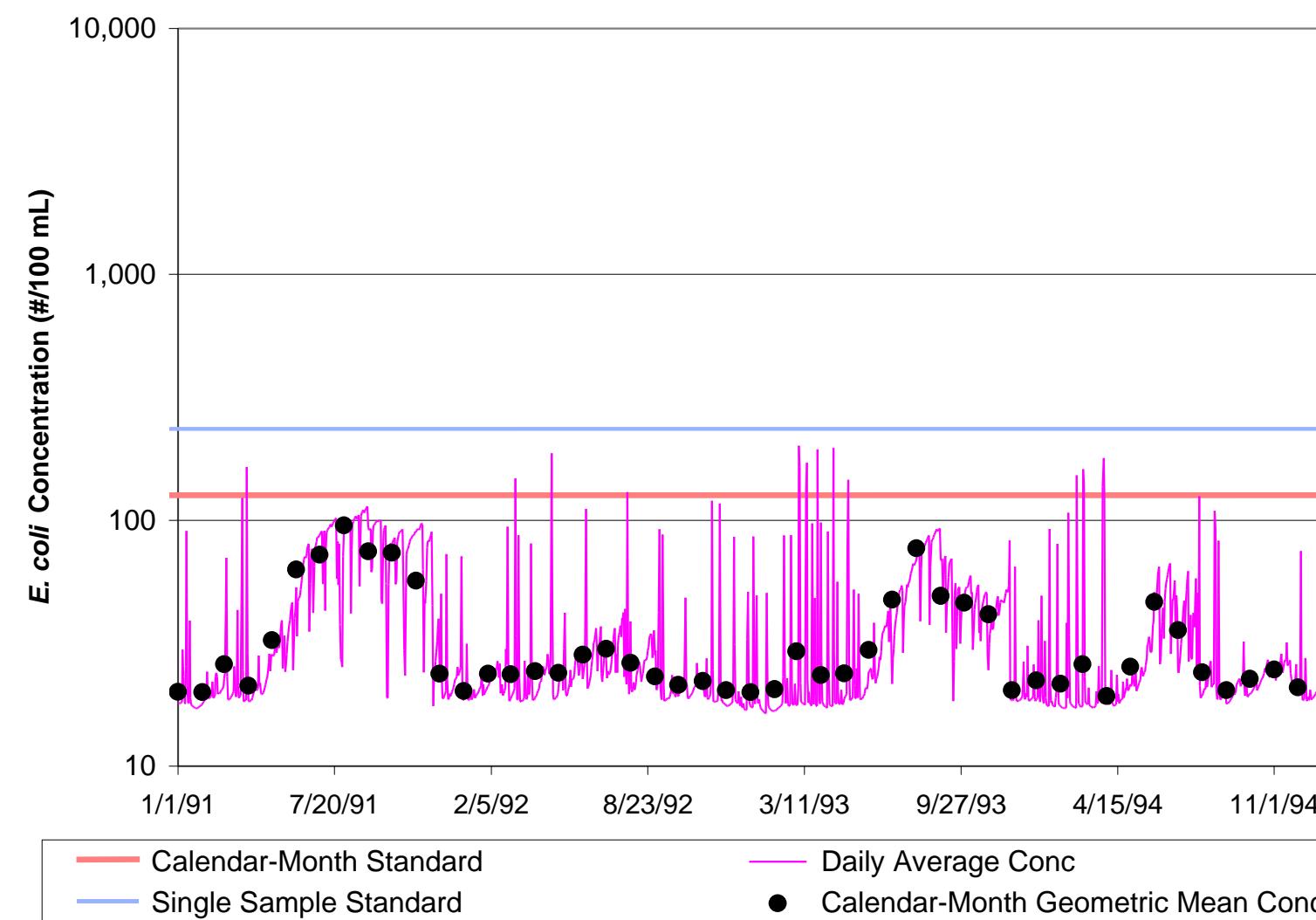


Calendar-month geometric mean *E. coli* concentration

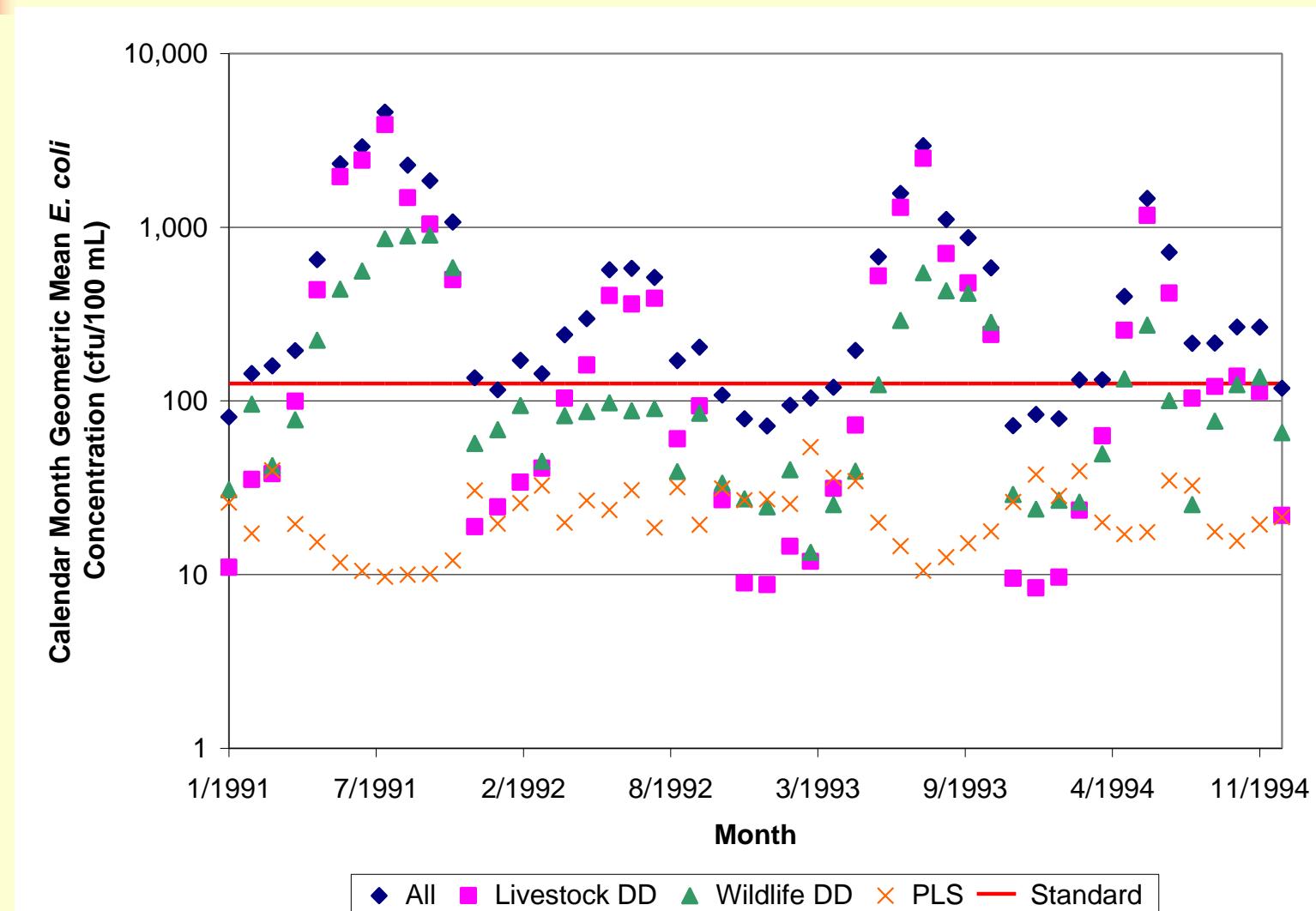
Bacteria TMDL Allocation Scenarios - Licking Run

Scenario Number	% Violation of E. coli Standard		Fecal Coliform Loading Reduction Required to Meet the <i>E.coli</i> Standards, %					
	Geo. Mean	Single Sample	Cattle DD	Cropland	Pasture	Wildlife DD	Forest PLS	All Residential PLS
Existing Conditions	63	46	0	0	0	0	0	0
01	27	21	95	90	90	0	0	90
02	27	19	99	99	99	0	0	99
03	0	0	99	95	95	90	0	90
04	0	0	99	95	95	90	0	0
05	0	0	99	25	95	90	0	0
06	0	0	99	0	95	90	0	0

Bacteria TMDL Allocation Scenario - Licking Run



Contribution by Source Category - Cedar Run

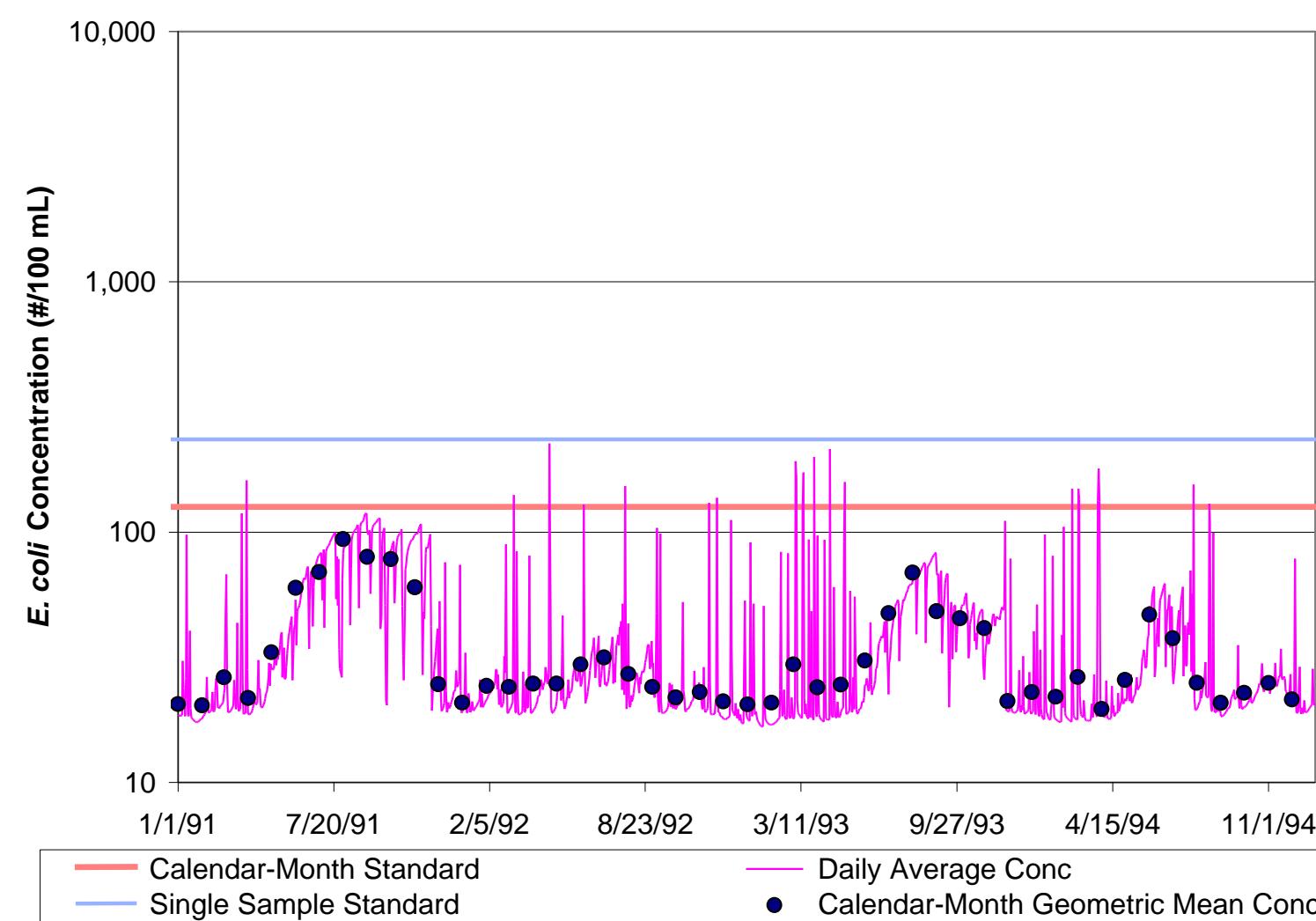


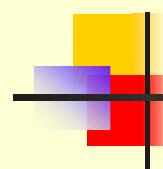
Calendar-month geometric mean *E. coli* concentration

Bacteria TMDL Allocation Scenarios - Cedar Run

Scenario Number	% Violation of E. coli Standard		Fecal Coliform Loading Reduction Required to Meet the <i>E.coli</i> Standards, %					
	Geo. Mean	Single Sample	Cattle DD	Cropland	Pasture	Wildlife DD	Forest PLS	All Residential PLS
Existing Conditions	75	51	0	0	0	0	0	0
01	44	27	95	90	90	0	0	90
02	38	25	99	99	99	0	0	99
03	4	0	99	95	95	90	0	95
04	0	1	99	95	95	95	0	0
05	0	0	99	95	95	95	0	25
06	0	0	99	0	95	95	0	95

Bacteria TMDL Allocation Scenario - Cedar Run

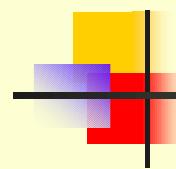




Bacteria TMDLs

Watershed	TMDL ($\times 10^{10}$ cfu/yr)	SWLA ($\times 10^{10}$ cfu/yr)	SLA ($\times 10^{10}$ cfu/yr)	MOS*
Licking Run	963.7	0.3	963.4	--
Cedar Run excluding Licking Run	6,958	8.7	6,949	--
Cedar Run including Licking Run	7,921	9.0	7,912	--

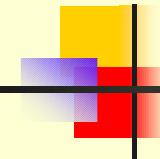
*Implicit MOS



Stage 1 Implementation Objective

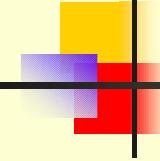
- Eliminate wildlife reductions and, if possible, reduce violation rate of the instantaneous standard (235 cfu/100 mL) to 10%

- Adaptive Implementation
 - Gradual BMP implementation
 - Continuous assessment
 - Water quality monitoring



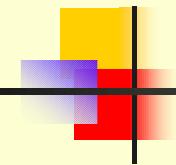
Stage 1 Implementation Scenarios-Cedar Run

Scenario Number	% Violation of <i>E. coli</i> Single Sample Standard	Fecal Coliform Loading Reduction Required to Meet the <i>E.coli</i> Standards, %					
		Cattle DD	Cropland	Pasture	Wildlife DD	Forest PLS	All Residential PLS
Existing Conditions	46	0	0	0	0	0	0
01	25	99	0	95	0	0	95



Stage 1 Implementation Scenarios-Licking Run

Scenario Number	% Violation of <i>E. coli</i> Single Sample Standard	Fecal Coliform Loading Reduction Required to Meet the <i>E.coli</i> Standards, %					
		Cattle DD	Cropland	Pasture	Wildlife DD	Forest PLS	All Residential PLS
Existing Conditions	51	0	0	0	0	0	0
01	19	99	0	95	0	0	0



What's Next?

- TMDL Report available for review:
www.deq.state.va.us/tmdl/tmdlrpts.html

- 30 day public comment
- Make appropriate changes
- Submit report to EPA for approval
- Develop an implementation plan